AMENDMENTS TO THE SPECIFICATION

Please enter the following paragraphs of the Specification, as amended, to replace the previously submitted respective paragraphs.

Paragraph **0001** of the Specification on Page 1 should read as follows:

[0001] This application is a Continuation-In-Part of ~~pending~~ U.S. Patent Application Serial Number 10/268,466 filed October 9, 2002, which issued on November 18, 2003 as U.S. Patent 6,651,035 for which priority is claimed and is incorporated herein by reference in its entirety. Application Serial Number 10/268,466 which, in turn, is a Continuation-In-Part of ~~pending~~ U.S. Patent Application Serial Number 10/131,932 filed April 24, 2002, which issued on June 1, 2004 as U.S. Patent 6,745,152 for which priority is claimed and is incorporated herein by reference in its entirety. Application Serial Number 10/131,932 which, in turn, is a Continuation-In-Part of U.S. Patent Application Serial Number 09/273,711 filed March 22, 1999, which issued on February 18, 2003 as U.S. Patent 6,522,994 and is incorporated herein by reference in its entirety; Application Serial Number 09/273,711 which, in turn, is a Continuation-In-Part of U.S. Patent Application Serial Number 09/047,198 filed March 24, 1998 now abandoned.

Paragraph **0003** of the Specification on Pages 1 and 2 should read as follows:

[0003] Application Serial Number 10/131,932 is also a Continuation-In-Part of ~~pending~~ U.S. Patent Application Serial Number 10/087,879 filed March 1, 2002, which issued on March 30, 2004 as U.S. Patent 6,714,877 and is incorporated herein by reference in its entirety; Application Serial Number 10/087,879 which, in turn, is a Continuation-In-Part of U.S. Patent Application Serial Number 09/273,711 now U.S. Patent 6,522,994; Application Serial Number 09/273,711 which, in turn, is a Continuation-In-Part of U.S. Patent Application Serial Number 09/047,198 now abandoned. Application 10/087,879 is also a Continuation-In-Part of U.S. Patent Application Serial Number 09/630,853 now U.S. Patent 6,584,429; Application Serial Number 09/630,853 claims the benefit of U.S. Provisional Patent Application Serial Number 60/147,717. Application 10/087,879 is also a Continuation-In-Part of U.S. Patent Application Serial Number 09/827,956 filed April 4, 2001, which issued on May 6, 2003 as U.S. Patent 6,560,563 and is incorporated herein by reference in its entirety; Application Serial Number 09/827,956 which, in turn, is a Continuation-In-

Part of U.S. Patent Application Serial Number 09/759,061 filed January 11, 2001 now abandoned; Application Serial Number 09/759,061 which, in turn, is a Continuation-In-Part of US Patent Application Number 09/273,711 now U.S. Patent 6,522,994; Application Serial Number 09/273,711 which, in turn, is a Continuation-In-Part of U.S. Patent Application Serial Number 09/047,198 now abandoned. Application 10/087,879 is also a Continuation-In-Part of ~~pending~~ U.S. Patent Application Serial Number 09/971,527 filed October 5, 2001 , which issued on March 29, 2005 as U.S. Patent 6,873,933; Application Serial Number 09/971,527 which, in turn, is a Continuation-In-Part of U.S. Patent Application Serial Number 09/273,711 now U.S. Patent 6,522,994; Application Serial Number 09/273,711 which, in turn, is a Continuation-In-Part of U.S. Patent Application Serial Number 09/047,198 now abandoned; Application Serial Number 09/971,527 is also a Continuation-In-Part of U.S. Patent Application Serial Number 09/630,853 now U.S. Patent 6,584,429; Application Serial Number 09/971,527 is also a Continuation-In-Part of U.S. Patent Application Serial Number 09/827,956 now U.S. Patent 6,560,563; Application Serial Number 09/827,956 which, in turn, is a Continuation-In-Part of U.S. Patent Application Serial Number 09/759,061 now abandoned; Application Serial Number 09/759,061 which, in turn, is a Continuation-In-Part of US Patent Application Number 09/273,711 now U.S. Patent 6,522,994; Application Serial Number 09/273,711 which, in turn, is a Continuation-In-Part of U.S. Patent Application Serial Number 09/047,198 now abandoned.

Paragraph **0005** of the Specification on Pages 2 and 3 should read as follows:

[0005] Although especially applicable to "The Input/Loss Method" as installed at recovery boilers burning black liquor, this invention may also be applied to any other of the "Input/Loss methods" installed at any thermal system burning a fossil fuel. The teachings of this invention may be implemented for monitoring of any thermal system burning a fossil-fuel, or a thermal system burning a mix of fossil fuels and inorganic fuels. Such monitoring is assumed to be conducted in a continuous manner (i.e., on-line), processing one monitoring cycle after another, each cycle includes determining stoichiometric balances of the combustion process and, specifically, the fuel's chemistry, heating value, boiler efficiency, system efficiency and evaluation for possible tube failures. Specifically, The Input/Loss Method and its associated technologies are described in the following U.S. Patents ~~and patent applications~~ (cited above): U.S. Patent 6,522,994 (hereinafter termed '994), U.S. Patent 6,584,429 (hereinafter termed '429), U.S. Patent 6,560,563 (hereinafter termed '563), U.S. Patent 6,714,877 ~~Application 10/087,879~~ (hereinafter termed '879 after its

application 10/087,879), U.S. Patent 6,651,035 (hereinafter termed '035) and U.S. Patent 6,745,152 ~~Application 10/131,932~~ (hereinafter termed '932 after its application 10/131,932) ~~; and in any of their related provisional patent applications and Continuation-In-Parts~~. One of the Input/Loss methods, a rudimentary method, is described in U.S. Patent 5,367,470 issued November 22, 1994 (hereinafter termed '470), and in Patent 5,790,420 issued August 4, 1998 (hereinafter termed '420).

Paragraph **0008** of the Specification on Pages 3 and 4 should read as follows:

[0008] The problem of tube failures in recovery boilers, in addition to the conventional problems cited above, is when water comes in contact with the molten smelt (typically at over 1400 F, ~~with heavy concentrations~~ having a heavy concentration of sodium); explosion is likely and may occur within minutes after tube failure. Recovery boiler explosions have dogged the pulp and paper industry since inception of the pulp producing process (i.e., called the Kraft process). Recovery boiler explosions injure and kill people every year. From 1948 through 1990 the industry recorded 140 recovery boiler explosions, three-quarters of which were smelt-water explosions. To place emphasis on the problem, the industry ranks explosions by severity: by definition just a "moderate explosion" keeps the plant off-line from 10 to 50 days; whereas a severe explosion keeps the plant off-line more than 50 days (typically lasting more than 120 days).

Paragraph **0016** of the Specification on Page 7 should read as follows:

[0016] This invention adds to the technology associated with Input/Loss methods. Specifically The Input/Loss Method has been applied through computer software, installable on a personal computer termed a "Calculational Engine", and has been demonstrated as being highly useful to the operators of fossil-fired systems. The Calculational Engine receives data from the system's data acquisition devices. The Calculational Engine's software consists of the EX-FOSS, FUEL and HEATRATE programs described in '994 and '429, and in FIG.2 herein, and the ERR-CALC program described in '879 (also ~~employed~~ described in '035 and '932) and in FIG.3 herein. ERR-CALC now incorporates the teachings of this invention. The Calculational Engine continuously monitors system efficiency on-line, i.e., in essentially real-time, as long as the thermal system is burning fuel. The application of this invention to The Input/Loss Method significantly enhances the system operator's ability to predict tube failures and reduce outage time required for repair.

Paragraph **0024** of the Specification on Page 8 should read as follows:

[0024] FIG.2 and FIG.3 relate the interactions of the computer programs which implement this invention. The majority of the teachings of this invention are implemented in the ERR-CALC program. The FUEL, EX-FOSS and HEATRATE programs ~~remain substantially unchanged as~~ are used to implement both the teachings of '994 and '429 , and the sodium-based stoichiometrics as taught herein. The ~~However the~~ FUEL, EX-FOSS and HEATRATE programs employ ~~the~~ results from ERR-CALC, including its calculated tube leakage flow rate, and thus assess the impact ~~of~~ such leakage has on the thermal system in terms of boiler efficiency, fuel flow and system efficiency. Further, through energy balances on the steam generator's working fluid, and use of iterative procedures involving these programs, determination is then made within HEATRATE as to which heat exchanger within the steam generator contains the failed tube.

Paragraph **0026** of the Specification on Pages 8 and 9 should read as follows:

[0026] To assure an appropriate teaching of this invention, its description is divided by sub-sections. The first two present nomenclature, definitions of equation terms, typical units of measure, and meaning of terms used herein (such as Choice Operating Parameters and System Effect Parameters), encompassing ~~Paragraphs 0027 through 0043~~ the following seventeen paragraphs. The remaining sub-sections, representing the bulk of the teachings, are divided into four general groups:

1) the first group presents system stoichiometrics applied to recovery boilers and the determination of fuel chemistry based on effluents, these teachings support all subsequent disclosures herein (encompassing ~~Paragraphs 0044 through 0062~~ the sub-section entitled "System Stoichiometrics", employing equations numbered less than one-hundred);

2) the next group presents the determination of boiler efficiency for a black liquor-fired boiler as it influences both tube failure flow rate and determining tube failure location (encompassing ~~Paragraphs 0063 through 0075~~ the sub-section entitled "Boiler Efficiency for Recovery Boilers", employing equations numbered in the one-hundreds);

3) the next group teaches how a tube failure may be detected based on an ability to correct Choice Operating Parameters using multidimensional minimization techniques, this ability being dependent, in part, on system stoichiometrics, the computed fuel chemistry and boiler efficiency (encompassing ~~Paragraphs 0076 through 0108~~ five sub-sections starting with "Tube Failure Detection Methods" and ending with "Objective Function and Choice

Operating Parameters", employing equations numbered in the two-hundreds); and

4) the last group teaches how both the tube leakage flow rate and its location in the steam generator are determined using, as a foundation, the preceding teachings (encompassing ~~Paragraphs 0109 through 0119~~ sub-sections entitled "Tube Leakage Flow Rate Computations" and "Tube Leak Location", employing equations numbered in the three-hundreds).

The remaining paragraphs present a conclusion, THE DRAWINGS and related teachings. Teachings of multidimensional minimization techniques, as directly applicable to this invention are also presented in '879, '035 and '932. The present invention expands the utility of Input/Loss methods to recovery boilers, and specifically builds upon and expands the utility of The Input/Loss Method described herein and in '994, '429, '879, '035 and '932, and in '563 as it teaches the L Factor. The methods described in '563 teach the foundations of the L Factor used in multidimensional minimization techniques; the L Factor is further expanded as taught herein to encompass black liquor fuels used in recovery boilers.

Paragraph **0041** of the Specification on Page 18 should read as follows:

[0041] As used herein, the meaning of the words "Fuel Iterations", are defined in conjunction with a detailed description of FIG.2 found within THE DRAWINGS, said Fuel Iterations specifically refers to items 260, 270, 280, 285 and 287 of FIG.2.

Paragraph **0070** of the Specification on Pages 36 and 37 should read as follows (note that the only changes occur in the last two sentences, and that *no equation has been changed*):

[0070] The Enthalpy of Reactants (HRX_{Act}) term is as follows. Note that although SO_2 is a common gaseous product of ideal combustion of conventional fossil fuels, it is not assumed to be produced from the ideal combustion of black liquor. For higher heating value calculations:

$$\begin{aligned} HRX_{Act\text{-}HHV} \equiv\ & HHVP + HBC \\ & + HPR_{CO2\text{-}Ideal} + HPR_{H2O\text{-}Ideal\text{-}HHV} \\ & + HPR_{Na2CO3\text{-}Ideal} + HPR_{Na2SO4\text{-}Ideal} \\ & + HPR_{NaCl\text{-}Ideal} + HPR_{K2CO3\text{-}Ideal} \end{aligned} \tag{135}$$

For lower heating value calculations:

$$
\begin{aligned}
HRX_{Act\text{-}LHV} \equiv\ & LHVP + HBC \\
& + HPR_{CO2\text{-}Ideal} + HPR_{H2O\text{-}Ideal\text{-}LHV} \\
& + HPR_{Na2CO3\text{-}Ideal} + HPR_{Na2SO4\text{-}Ideal} \\
& + HPR_{NaCl\text{-}Ideal} + HPR_{K2CO3\text{-}Ideal}
\end{aligned}
\tag{136}
$$

where: $HPR_{CO2\text{-}Ideal}$ = Energy of CO_2 ideal product from complete combustion at the calibration temperature.

$\equiv \Delta H^0_{f\text{-}Cal/CO2}\ \alpha_4\ N_{CO2}/N_{AF}$

$HPR_{H2O\text{-}Ideal\text{-}HHV}$ = Energy of H_2O ideal product from complete combustion, ending with condensed water, at the calibration temperature.

$\equiv (\Delta H^0_{f\text{-}Cal/liq} N)_{H2O}\ \alpha_5 / N_{AF}$

$HPR_{H2O\text{-}Ideal\text{-}LHV}$ = Energy of H_2O ideal product from complete combustion, ending with water vapor, at the calibration temperature.

$\equiv (\Delta H^0_{f\text{-}Cal/vap} N)_{H2O}\ \alpha_5 / N_{AF}$

$HPR_{Na2CO3\text{-}Ideal}$ = Energy of Na_2CO_3 ideal product from complete combustion at the calibration temperature.

$\equiv \Delta H^0_{f\text{-}Cal/Na2CO3}\ \sigma_N\ T_{NO}\ N_{Na2CO3} / (xN_{AF})$

$HPR_{Na2SO4\text{-}Ideal}$ = Energy of Na_2SO_4 ideal product from complete combustion at the calibration temperature.

$\equiv \Delta H^0_{f\text{-}Cal/Na2SO4}\ \sigma_N T_{NA}\ N_{Na2SO4} / (xN_{AF})$

$HPR_{NaCl\text{-}Ideal}$ = Energy of NaCl ideal product from complete combustion at the calibration temperature.

$\equiv \Delta H^0_{f\text{-}Cal/NaCl}\ \sigma_N T_{NC}\ N_{NaCl} / (xN_{AF})$

$HPR_{K2CO3\text{-}Ideal}$ = Energy of K_2CO_3 ideal product from complete combustion at the calibration temperature.

$\equiv \Delta H^0_{f\text{-}Cal/K2CO3}\ \sigma_N\ T_{KO}\ N_{K2CO3} / (xN_{AF})$

It should be noted that in ~~Paragraphs 0069 and 0070 when using~~ <u>this and in the preceding paragraph</u> the fuel's calorimetric temperature, established when determining the fuel's heating value, <u>is used</u> as the thermodynamic reference energy level for the Enthalpy of Products and for the Enthalpy of Reactants<u>; these two enthalpies employ a corrected Heat</u> ~~, that these include corrected Heats~~ of Formation <u>term</u>, $\Delta H^0_{f\text{-}Cal/i}$ <u>,</u> ~~for example as~~ taught by Eq.(134), ~~said the $\Delta H^0_{f\text{-}Cal/i}$ term~~

~~being~~ as used in Eqs.(131), (132), (133), (135) and (136). ~~Further, that~~ As seen in Eq.(134), $\Delta H^0_{f\text{-}Cal/i}$ is corrected relative to a standard Heat of Formation for substance i, taken at 77 F (25 C) and denoted by $\Delta H^0_{f\text{-}77/i}$.

Paragraph **0080** of the Specification on Page 44 should read as follows:

[0080] It is an important aspect of the present invention that it may be integrally involved with any of the Input/Loss methods which compute fuel chemistry. As seen with the ~~used~~ use of TABLE 1A, without a determination of fuel chemistry, i.e., computing α_i quantities based on consistent stoichiometrics (with or without tube leakage), then the use of Eq.(200) as taught herein to detect tube leaks would become limited. More specifically, this invention is integrally involved with The Input/Loss Method of '994 and '879 as the determination of fuel chemistry is then based on a selection of Choice Operating Parameters which might well require corrections for stoichiometric consistencies. For example, if effluent water was being measured, but whose signal was not corrected for stoichiometric consistency as taught in '879, resolution of tube leaks (even with computed α_i quantities) would be hampered; especially so if fuel chemistry was assumed constant.

Paragraph **00114** of the Specification on Page 62 should read as follows (note that the last two sentences were changed, as was column 2 of TABLE 2):

[0114] To further assist in teaching this invention, TABLE 2 presents a typical scenario of routine monitoring, the identification of a possible tube leak, and then the resolution of the tube leakage flow rate. In TABLE 2, the second column denotes the selection of Choice Operating and System Effect Parameters; for example, "Λ_{1S} min L'_{Fuel}" means that Choice Operating Parameter Λ_{1S}, see Eq.(211S), is selected to minimize the error in System Effect Parameter L'_{Fuel}. The use of "Λ_{1S} min L'_{Fuel}", "Λ_{2S} min L'_{Fuel}", ~~and~~ "Λ_4 min L'_{Fuel}", "Λ_{7B} min L'_{Fuel}" and "Λ_9 min L'_{Fuel}" used in Pass 0 is typical for the assumed thermal system if burning black liquor fuel. However if ~~If~~ measuring Stack O_2 instead of Boiler O_2 as used in TABLE 2, the selection would typically consist of only "Λ_{1S} min L'_{Fuel}", ~~and~~ "Λ_{2S} min L'_{Fuel}", "Λ_{7S} min L'_{Fuel}" and "Λ_9 min L'_{Fuel}".

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TABLE 2: Example of Determining Tube Failure Flow Rate using the Preferred Embodiment

The Thermal System and Computational Sequence	Optimizations	Comments
Routine monitoring of a black liquor-fired system having high water, low & constant inerts; multiple O_2 instruments are used at the Boiler having high accuracy; CO_2 & H_2O Stack instruments; uncertain air leakage. Defines Pass 0.	Λ_{1S} min L'_{Fuel} Λ_{2S} min L'_{Fuel} Λ_4 min L'_{Fuel} Λ_9 min L'_{Fuel} $\underline{\Lambda_{7B}\ \text{min}\ L'_{Fuel}}$	Compute As-Fired fuel chemistry with constant fuel inerts every 3 minutes; optimization of Choice Operating Parameters every 30 minutes using BFGS technique with Tube Failure Model option invoked. Historically: $C_{1S} = 0.96$, $C_{2S} = 1.02$ and $C_4 = 1.10$.
A possible tube failure has been detected given Tube Failure Mechanism 51 (see TABLE 1A). Use historical values for C_{1S} & C_{2S}; $\Lambda_{0-8} = 500$ lb/hr. Defines Pass 1.	Λ_4 min L'_{Fuel} Λ_8 min WF_{H2O} $\underline{\Lambda_{7B}\ \text{min}\ L'_{Fuel}}$ $\underline{\Lambda_9\ \text{min}\ L'_{Fuel}}$	Compute As-Fired fuel chemistry with constant fuel inerts; optimization using Simulated Annealing. Results in the computed tube leakage flow rate, m_T, which satisfies stoichiometrics.
Return to routine monitoring but including the computed tube leakage flow rate, m_T, but excluding effluent water ($C_{2S} = 1.02$). Defines Pass 2.	Λ_{1S} min L'_{Fuel} Λ_4 min L'_{Fuel} $\underline{\Lambda_{7B}\ \text{min}\ L'_{Fuel}}$ $\underline{\Lambda_9\ \text{min}\ L'_{Fuel}}$	Compute As-Fired fuel chemistry as in Pass 0, resulting in converged Choice Operating Parameters associated with the computed tube leakage flow rate.